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SUGGESTIONS FOR IMPROVED METHODS OF MINING COAL ON INDIAN LANDS IN OKLAHOMA

BY

J. J. RUTLEDGE AND DANIEL HARRINGTON

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SUGGESTIONS FOR IMPROVED METHODS OF MINING COAL ON INDIAN LANDS IN OKLAHOMA.

By J. J. RUTLEDGE and DANIEL HARRINGTON.

INTRODUCTION.

On February 11, 1913, the Secretary of the Interior charged the Bureau of Mines with the duty of inspecting the operations of the coal, asphalt, and other mines belonging to the Choctaw and Chicasaw Indians in Oklahoma, and of all like mines belonging to Indians and Indian tribes, wherever located.

The Bureau of Mines has made an extensive investigation of conditions in the coal mines in the segregated Indian lands, with a view to increasing safety and improving the mining methods employed. In the past much waste has occurred, and the steep pitch of the beds, the weak roof, and the presence of much gas makes mining difficult in many of the mines. This report describes the systems of mining used, points out their defects, and presents suggestions for improved methods, more especially as regards the applicability of different modifications of the panel system to mining coal in Oklahoma.

ACKNOWLEDGMENT.

The writers cordially acknowledge the valuable suggestions of George S. Rice, chief mining engineer, Bureau of Mines, in regard to the preparation of this paper and also the aid of J. W. Koster, junior mining engineer, Bureau of Mines, in preparing drawings and sketches and in making calculations.

CHOCTAW AND CHICKASAW COAL LANDS.

The segregated coal lands of the Choctaw and Chickasaw tribes comprise about 440,000 acres in eastern Oklahoma, formerly known as Indian Territory. The surface of the lands has been sold, but the coal has been reserved and is the tribal or communal property of these two tribes. About 120,000 acres of this coal land were under lease in June, 1917, and mines are being worked on most of the leases. The remainder is virgin territory.

CHARACTER OF COAL BEDS.

The coal-bearing beds of the segregated Indian lands lie in comparatively shallow synclines. All the coal, which is bituminous and semibituminous, is associated with shales and sandstones. In some mines the coal is somewhat easily broken and generally yields considerable dry and inflammable dust during mining. Usually the roof is friable shale and the floor fairly hard shale. In general, the floor does not readily heave. The coals outcrop along the rims of the basins and their outcrops are usually not well defined, being mostly covered with soil.

COAL BEDS MINED.

Mining generally is confined to five or six beds, the five of chief importance being the McAlester, the Hartshorne (Upper and Lower), the Arkansas or Panama, and the Witteville. Several other beds that have not been definitely correlated are worked locally, among them being the Secor and Cavanal.

The McAlester coal, which is worked at the western end of the field, varies from 2½ feet to 3 and 4 feet in thickness and in places it occasionally, but rarely, is 5 feet thick. The coal lies under a fairly good shale roof, is rather hard, and makes an excellent domestic fuel. The average dip of the bed ranges from 5° to 10°; in a few places it becomes as much as 30° to 50° and even 55°.

Of the two Hartshorne beds, the Lower is by far the more important, as it extends throughout almost the entire coal field and is decidedly persistent. The Lower Hartshorne coal is 3½ to 4 feet thick and in a few places 5 to 6 feet; its dip varies from 5° or 6° to as much as 50°. The coal is softer than the McAlester coal and is generally used for steam purposes, though formerly it yielded an excellent coke in beehive ovens. The McAlester coal also was coked in beehive ovens and gave an excellent coke. The Lower Hartshorne bed is free from persistent partings.

An interval of 60 to 90 feet separates the Lower Hartshorne from the Upper Hartshorne bed. The Upper Hartshorne is 2 to 3 feet and occasionally as much as 4 feet thick. Generally the coal is free from partings and is fairly soft. Only a few openings have been made in this bed, and their output is very small. In the east-central part of the coal field, the two Hartshorne beds approach so closely that only a few feet of shale separates them.

Important mines have been opened in the Hartshorne seam near the towns of Haileyville, Hartshorne, Gowan, and Wilburton.

The Panama, or so-called Arkansas bed, is near the Oklahoma-Arkansas boundary. It furnishes a good quality of railroad and steam coal.

METHOD OF WORKING COAL MINES ON INDIAN LANDS IN OKLAHOMA.

The earliest mining was by beginning at the outcrop and driving slopes in the coal directly down the dip. This plan has been followed almost exclusively, and in consequence nearly all of the mines are of relatively small output and require little initial investment and working capital. All mining companies lease directly from the Choctaw and Chickasaw Tribes, the owners of the coal, and pay a royalty of 8 cents a ton of 2,000 pounds, run-of-mine coal, including what is ordinarily known as slack. Much of the best crop coal in the vicinity of McAlester, which is the largest city in the field and is the business center, has been mined, and several companies have lately sunk vertical shafts to the coal near the middle of the basins and have begun mining from these shafts. These companies hope by mining in this way to recover more coal, decrease mining costs, and lessen the danger from mine squeezes. To sink and equip these deep shafts necessitates large expenditures, and if followed will necessarily result in the gradual elimination of operators with small capital from this field.

Thus far the usual procedure in opening a mine has been to drive a main slope directly down the dip, or pitch, of the coal bed, with an air course on each side, parallel to the slope and separated from it by pillars 15 to 50 feet thick, the usual thickness being about 20 feet. The slopes are generally 10 to 12 feet wide, are brushed to a height of 5 or 6 feet from the rail, and uniformly have only one track. The air courses are 6 to 8 feet wide and are not always brushed. The slopes rarely exceed 3,000 feet in length, although a few are about a mile long.

Lifts, or cross entries, are turned directly off the slopes at intervals varying from 100 to 300 and 400 feet, depending on the dip of the bed, and consequently the distance to which rooms can economically be driven up or down the pitch.

In none of the mines thus far opened are more than four or five cross entries worked at once on each side of the slope; and rarely are there as many as 10 working rooms on any cross entry, the usual number being about seven or eight. In several mines more than 100 rooms have been turned off one cross entry, but only the seven or eight rooms nearest the face of the entry are working, all the rest having been worked out, so that the long entry with its tracks and timbering is maintained solely for the coal produced in the few rooms worked. Consequently outputs are small and haulage costs high, and not one mine has ever produced 1,000 tons of coal a day regularly for any considerable time. The report of the Oklahoma State

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mine inspection department for the year ended June 30, 1915, shows that only 25 per cent of the mines had an average daily output of more than 300 tons, and that the maximum average daily production was less than 800 tons.

In most mines the rooms are turned directly off the lifts, or cross entries, and driven straight up the dip. Where the dip is too slight for chute and flat-sheet work and too heavy to permit the mules to pull readily the empty mine cars directly up the pitch to the face, the rooms are turned off the cross entries at angles of 20° to 45°, that is, they are driven across the pitch. In rooms where the cars are pulled to the face by mules, the roadway must be brushed to mule height.

Room centers are generally spaced 30 to 40 feet, the rooms being 20 to 30 feet wide and the pillars 6 to 10 feet thick. In most of the mines little or no attempt is made to recover these thin room pillars, although a few mines endeavor to draw pillars. In a few mines the recovery of the coal in the bed may be as much as 60 per cent, although the usual proportion is about 50, and in many mines is as low as 45 per cent. Most of the coal has been won by shooting off the solid, and explosions have been frequent and sometimes disastrous to life and property. Until about 1914, only black blasting powder and dynamite were used to shoot the coal. Since that time several mines have adopted mining machines and permissible explosives, and many of the mines shooting off the solid have begun to use permissible explosives.

Many of the crop workings from which had been mined all the coal that could profitably be extracted by the method described above have been abandoned and allowed to fill with water and gas, thus becoming a menace to adjoining mines and an almost insurmountable obstacle to mining below on the dip. The small mine has been the rule rather than the exception, and on some leases it was formerly customary to open one mine on each 40-acre tract, and abandon the mine when the workings reached the boundary.

In several mines the long-wall advancing system was tried some years ago, but was later abandoned, although seemingly successful. However, this method of mining has been resumed lately in one mine in the Lehigh district, where it until quite recently was in successful operation. In this mine the coal was undercut with electric mining machines. The method of panel long-wall mining, by machine and conveyor, has been tried for about 18 months past in one of the mines in the Alderson district and is meeting with some success. One mine has recently adopted the room-and-pillar panel method, another the retreating room-and-pillar plan.

DEFECTS OF PRESENT SYSTEM OF MINING.

Briefly the defects of the present system of mining are as follows:

Only about one-half of the coal in the seam is recovered, the rest being irretrievably lost; also owners of the land lose a royalty for this unrecovered coal. **Practically one ton of coal is left unmined, with great probability that it will never be recovered, for every ton mined. Moreover, many mines working under the method now generally used have experienced squeezes.**

The average daily production per mine is small, consequently the overhead and fixed charges are comparatively large and the total cost of production is high, a condition that is bad for miners, operators, the community in general, and the Indian owners.

The expense for dead work is excessive; yardage, including brushing, amounts to as much as 30 cents a ton of coal produced. Other cost items are also excessively high—much higher than in competing fields—and the operators must have some relief if they are to compete with those of other States. The proportion of fine coal, for which the market is limited and the selling price very low, is frequently as much as one-half of the entire output of a mine.

The system of working used at present does not permit concentration of mine work. Also numerous fires, explosions, and squeezes traceable to the defects of this system have worked hardships on the miners, the operators, the general community, and the Indian land owners, through the loss of life, of wages, and of property.

EXAMINATION OF MINES ON INDIAN LANDS.

An examination of all mines on the segregated coal lands of the Indian tribes was made by engineers of the Bureau of Mines during the first six months of 1915. The suggestions contained in this report are the results of this examination.

During January, February, March, April, and May, 1915, these engineers visited 59 mines and made individual recommendations. The average total daily output of the mines visited was about 18,000 tons, and the annual production was approximately 3,000,000 tons. Thirty-nine are slope mines and 20 are shaft mines. In 23 of the mines the dip was less than 10°, in 28 it was 10° to 30°, and in 8 more than 30°. Thirty of the mines have at some period suffered more or less from squeezes in which a part of the property was lost. Twenty-three have had explosions causing loss of life or property; and in addition in six other mines serious fires have happened, and in five men have been seriously burned by gas. Of the mines visited 18 are mining the McAlester coal. 10 the Lehigh (McAlester), 18 the Lower

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Hartshorne, 3 the Upper Hartshorne, 8 the Panama, and 2 the Witteville, the thicknesses of coal mined being as follows:

Thickness of coal mined at the 59 mines visited.

Thickness of coal, inches.	Number of mines.
36 or less	3
Over 36 and under 42	13
Over 42 and under 48	9
Over 48 and under 54	24
Over 54 and under 60	3
Over 60 and under 66	4
Over 66 and under 72	0
Over 72	3
	59

Thirty-one of the mines are distinctly dry, 7 fairly dry, 2 partly dry and partly wet, 14 damp, and 5 wet. Eleven may be classed as free from explosive gas, 19 have small amounts of explosive gas, 26 may be classed as gaseous, and 3 are very gaseous.

In two of the mines all shots were fired by electricity from the surface; in the other 57 the shots were fired underground by shot firers after all other men were out. In 52 mines the rooms were shot with black blasting powder; in 3 with permissible explosives; and in 1 with permissible explosives and black blasting powder. One mine had no rooms. In entry work 21 mines used black blasting powder, 17 used permissible explosives, and 12 used both black blasting powder and permissible explosives. Four mines used "40 per cent" dynamite, 3 used black blasting powder and dynamite, and 1 used dynamite and permissible explosives.

As the generally adopted mining system is that of driving rooms up the rise from levels which feed a main slope as the main haulageway, the choice of machines for the present working mines resolves itself into selecting the kind of machine that is suited for cutting coal on various pitches. The coal itself is generally easy to cut, has comparatively few impurities that interefere with cutting, and is practically free from clay veins and horsebacks. Rolls are infrequent and floor conditions are generally favorable to the use of machines.

The machines in use in the mines are air-driven post punchers ("radialax" type) and electrically driven short-wall machines. It is found that the "radialax" machine may be used to advantage, particularly in small mines, for entry work both on the level and on pitches ranging up to 40°, for either undercutting or overcutting; whereas the electrically driven short-wall machine is successfully utilized on pitches as high as 11° in rise rooms, if the room tracks are laid with wooden rails. Although the "radialax" machine can be used on pitches ranging up to 40°, it is felt that the cost of power would be excessive for a large installation and resort must be had to some type of chain machine, preferably the short-wall type which is rapidly being adopted by progressive companies. In Oklahoma the limiting pitch on which this type of machine has successfully worked in rise rooms is about 11°, and more than half of the mines on the segregated Indian coal lands have pitches greater than 11°.

To meet this difficulty, and also to increase the percentage of total recovery, decrease costs, etc., the engineers of the Bureau of Mines, after a personal examination of all mines and a careful study of the natural conditions under which the lessees have to produce their coal, recommend the adoption of a room-and-pillar panel system for pitches of 5° to 30°, and a panel long-wall system for dips of more than 30°, also applicable to coal beds having less dip. Both of the latter systems are adaptations to coal mining of the old Cornish methods of working metal mines and are intended for use in coal beds dipping from zero to 60°. Evidently some modifications of these systems will be necessary where the dip is slight, especially as to arrangements for loadage and haulage. Descriptions of the proposed systems follow. No claim for entire originality is made for any of the systems described, as all are modifications of systems of mining observed by the authors in other fields. They are put forward tentatively in the hope that their presentation will result in discussion that will ultimately be of benefit to a coal-mining region sorely in need of help.

ROOM-AND-PILLAR PANEL SYSTEM FOR PITCHES OF 5° TO 30°.

The room-and-pillar panel system in which rooms are driven across the pitch, or approximately parallel to the strike of the bed, is used successfully for mining pitching beds with short-wall machines in some parts of the United States and Australia. By use of this system two mines in central Wyoming (the plan of one of these mines is shown in Plate I), working a coal bed that dips 18° to 22° and is about 8 feet thick, are able to produce upward of 1,000 tons each daily, all the coal mined being undercut with short-wall machines.

Main haulage slopes are driven on the dip of the bed, and from these slopes, at intervals of 600 to 650 feet, levels are driven in pairs, with 20 or 25 foot pillars between, at enough angle with the strike to give a down grade of about 1½ per cent toward the main slope. Auxiliary slopes, driven from these levels to the rise or to the dip at intervals of 600 to 650 feet, divide the mine into panels about 600 to 650 feet square. Below the lower of two levels a pillar approximately 50 or 60 feet thick is left, and the rooms are turned off the auxiliary slopes, the rooms being roughly parallel to the strike, but having a grade of at least 1 per cent in favor of the loaded cars. Nine or ten rooms are turned off each auxiliary slope at intervals of approximately 50 feet, the rooms being 20 to 22 feet wide, and the room pillars 28 to 30 or more feet thick, depending on the amount of cover. Rooms are made 250 to 300 feet long, and at least 100 feet of solid coal is left between the main slope, or its air courses, and the ends of the rooms turned off the first panel. The pillar above the first room of a panel, or that between the first room and the level entry above, should not be cut by crosscuts, nor should the pillar between the last room and the entry below.

At the top of each pair of auxiliary slopes are small air-driven or electrically driven hoists, 15 to 35 horsepower each, fitted with $\frac{5}{8}$ or $\frac{3}{4}$ inch steel haulage ropes. The loaded cars are pulled out of room necks and pulled up (or possibly dropped down) to small partings on the levels, where trips are made up for haulage by mules, or preferably by electric locomotives. The empties are taken one or two at a time from these partings and placed in the room necks from which the loads were taken, each empty car being pushed to the face of the room by the miner. A hoist man and a rope rider are required to handle cars on the auxiliary slopes, and taking one car at a time can bring out 80 to 120 loads in an 8-hour shift. Where cars each having a capacity of 3,000 pounds or less are used, two cars can be handled at a time and 150 to 175 cars could be readily pulled in 8 hours.

Ventilation is provided as follows: The air is split where the level entries intersect the main intake, and usually the air from the level entry is conducted up the rise into the panels, necessitating small overcasts at the intersection of panel slopes with level entries; the amount of air allowed each split should be approximately 10,000 cubic feet a minute. In this way all ventilation in the working districts may be made ascensional. Where in driving panel entries it is necessary to drive to the dip rather than to the rise, because of excessive gas or for other reasons, the ventilation may be taken down rather than up the pitch, and this has been done successfully.

USE OF SHORT-WALL MACHINES.

Short-wall machines of the Sullivan and the Goodman makes are moved from room neck to room neck by the small electric or air-driven hoists, and thence travel by their own power on the room track of 16 to 24 pound metal rails, the track being laid close to the lower rib of the room. The short-wall machine may "sump" along the lower rib just ahead of the room track and cut up the pitch along the room face, or it may be pulled to the upper rib and sump along that rib and cut down the pitch. With the nonreversible type of

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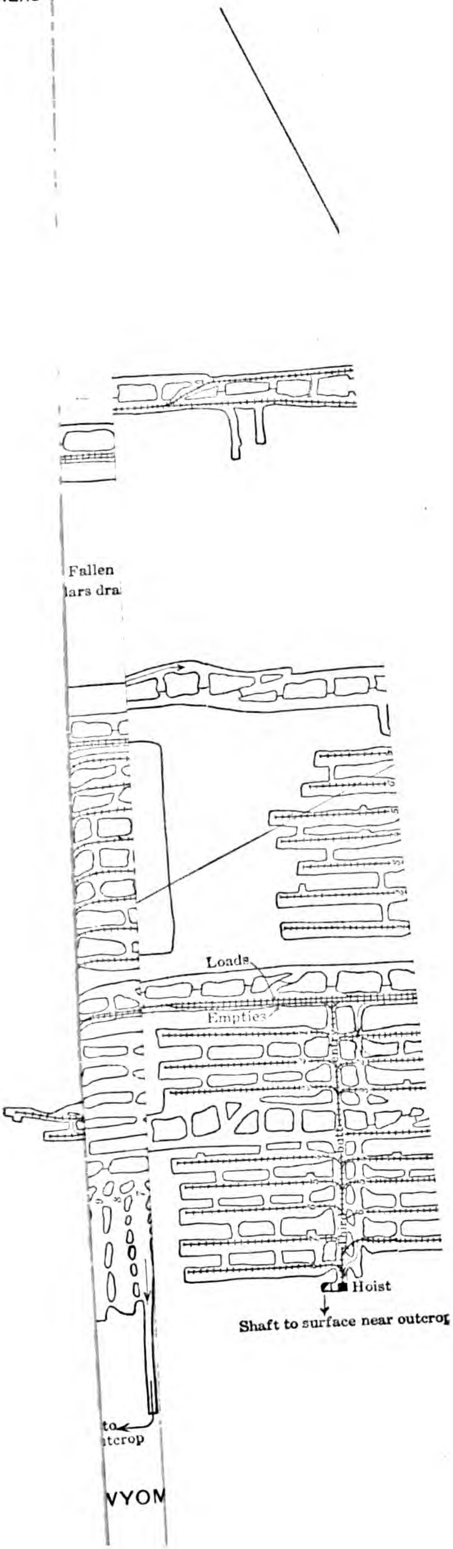
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machine it is necessary to sump on the lower rib in the rooms running one direction and on the upper rib in rooms running the opposite direction; with reversible machines, however, sumping may be done on either the lower or the upper rib as the runner desires, the practice varying.

Generally it is somewhat easier to sump along the lower rib, and in cutting along the face the machine will free itself of cuttings somewhat more readily in going up than in going down the pitch. However, expert runners frequently prefer to pull the machine empty to the upper rib and then sump, and become very proficient in doing this, the chief trouble being that the runner and his helper find it difficult to stand on the steep, smooth floor left from previous cutting.

Once the machine is ready to start a cut there is little difference in power used or time consumed between cutting along the room face directly up the pitch and cutting directly down the pitch. In cutting down the pitch the machine is in position to be placed on the truck immediately on completing the cut, whereas in cutting up the pitch the machine must be dragged through the coal cuttings down to the lower rib and turned parallel to the track before it can be placed on the truck. Experienced machine runners can cut six or seven places in an 8-hour shift and machine runners at all familiar with the work will readily average three places an 8-hour shift. Generally the bits are changed at least two or three times a shift. Practically all of the bits are pick bits. Some machine runners, however, demand chisel bits in the middle block of the chain; in this event the chisel bits are about 15 per cent of the whole number.

Cutting may be done during the regular operation of the mine, or may be done at night after the loaders have left. If done during the working shift, there may be delay in moving the machine from room neck to room neck by the rope or a delay in coal haulage or possibly both; whereas cutting on an off shift necessitates the presence of a man at the hoist on that shift.

In dry places short-wall machines are used to undercut entries straight up a 22° pitch, the greatest difficulty being to stand on the smooth floor left by the machine. It is difficult to get the machine to the face of entries with pitches up to 22° when the face is 100 feet or more from the level; hence, for driving entries up the pitch one machine is used for each pair of entries and is kept in the last crosscut when not in use.

The cost of labor, material, maintenance, repairs, and other items is somewhat higher than for machines operated in level workings, yet should vary little from three-fourths of a cent to 1½ cents per ton of coal cut, where an average amount of impurities is encountered in cutting.

Details of a proposed system of machine mining applicable to pitches of 5° to 30° are shown in Plate II.

PULLING PILLARS.

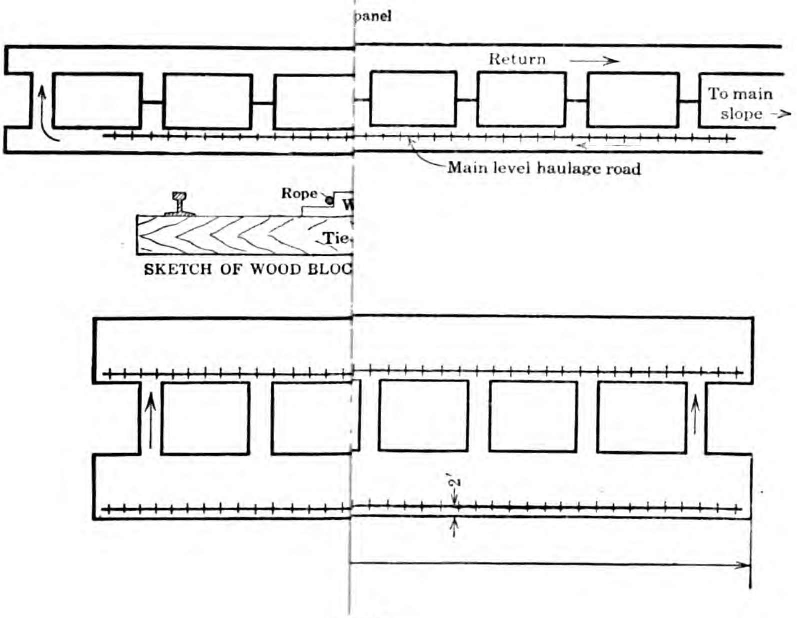
All the rooms in a panel should be driven abreast, as this gives maximum efficiency in ventilation and haulage, and permits attacking the pillars simultaneously. If it should be necessary to drive some rooms faster than others, the lower rooms should be chosen, and on their being driven to the desired distance pillar cutting (Pl. III) should be started. The cut on each pillar should be kept a trifle ahead of the cut on the one above it, in order to prevent falling material from being dangerous to men in open workings below. However, where the pitch is not more than 22°, no difficulty is found in keeping pillars abreast along a line parallel with the dip, as the falling material does not slide badly.

The pillars may be attacked with machines or with hand picks. Generally machines are the more satisfactory. Beginning at the face of the room, one or possibly two cuts are made by machine along the lower rib of the room for approximately 30 feet. As the short-wall machine does not readily free itself of "bug dust" when cutting to a dip of more than 16°, it is necessary not to exceed this angle in making the cuts; hence, the coal must be shot in two benches.

The coal from the cuts on the lower rib must be shoveled up the pitch to the track, as it is impracticable to drop the track down the pitch, owing to the difficulty of pushing loaded cars. Hence it is not wise to attempt to get more than two cuts from the lower rib. On the upper rib similar cuts are made from the face of the room for about 30 feet along the pillar until the cuts from the lower rib of the room above are met and the 30-foot length of pillar is removed.

A stump about 10 feet long is left intact and another section of the pillar is cut above and below as before outlined. The cuts are of such length as will leave 10 or 12 foot stumps inside the crosscuts made in driving the room, unless the crosscuts were more than 70 feet apart. After this section of the pillar has been removed, an attempt is made to remove the stump by pick and generally this is accomplished. When the coal is believed to be removed from a sufficient area (which in general should not be more than 100 feet in length along the room), the props are removed. If the roof will not cave, it is shot down. Occasionally the roof may cave before the props have been removed. It is necessary to prop closely while slicing the pillars in order to steady the roof and prevent the coal settling on the machines.

Pillar drawing is under the direction of an experienced man, who has charge of a panel of about 20 rooms. He sees that pillars are kept abreast on a predetermined line; that sufficient propping is



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done; and that props, rails, ties, etc., are removed at the proper time. Generally, pillar drawing is done only when the work can be continuous.

Where adequate pillars are left above and below a panel, not only is pulling the pillars within a panel generally accomplished without throwing additional weight on surrounding territory but it is the custom to relieve a too heavy weight on any area by extracting the pillars from a neighboring area. Pillar coal costs more than room coal, especially where rock has been gobbed in the room. **However, if the pulling of pillars keeps pace with development, so that the roof pressure does not become excessive, it is generally possible to get a larger percentage of lump from pillars than from rooms.** The extraction from a panel is generally about 90 per cent. Top coal, when present, is more difficult to recover and then the total recovery from a panel may be reduced to 80 or 85 per cent.

A comparison of the rise-room and the panel systems is shown in the following table:

Comparisons of the rise-room and the panel system of mining.

[Dips 16° to 30°.]

	Rise room.	Panel.
Length of rooms ... feet	100	300
Width of rooms ... do	24	24
Width of room pillars ... do	10	26
Pitch of coal ... degrees	16 to 30	16 to 30
Area of panel ... acres	9.42	9.42
Tons in panel (36-inch seam)	49,200	49,200
Number of rooms	76	22
Linear feet of—		
Entry	5,120	2,560
Entry crosscut	1,120	560
Room crosscut	3,040	2,000
Rooms	7,600	6,600
Main partings	600	300
Percentage of extraction in advance work:		
Rooms	40	35
Narrow work	27	17
Total	67	52
Percentage of extraction in retreat	0	32
Percentage of total extraction:		
Rooms	40	67
Narrow work	27	17
Total	67	84
Tons extracted per foot of entry:		
Advance work	3.60	5.00
Total	3.60	8.07

APPLICABILITY OF ROOM-AND-PILLAR PANEL SYSTEM TO OKLAHOMA MINES.

PULLING PILLARS.

In Oklahoma mines, under the present system of driving rooms up the rise, with its inadequate room and entry pillars which are usually too thin to be pulled, the maximum recovery of coal is about

60 per cent, and this can be obtained only under favorable conditions and no loss of coal from squeezes. Of 59 mines examined in 1915, 30 had lost standing coal through squeezes. If a panel system were installed in the 28 mines that have pitches of 10° to 30°, and in most of the 23 mines with pitches less than 10°, the extraction could readily be increased to 80 and even 90 per cent, provided adequate pillars were maintained in advancing and the pulling of pillars was started promptly on reaching the room lengths and was prosecuted vigorously and carefully. The pulling of pillars would undoubtedly eliminate squeezes, which, besides the loss of coal, have cost Oklahoma operators thousands of dollars for timber, rails, ties, pit cars, and other equipment, and for wages in attempting to limit squeezes and to recover squeezed areas. Moreover, miners have been endangered and lives lost through squeezes. In one instance an entire mine suddenly collapsed, killing 13 men, whose bodies were never recovered. Much of the so-called bad roof in the Oklahoma mines is caused by incipient squeezes and the trouble from it would be largely remedied if pillars were pulled and the weight relieved. Some mining men in Oklahoma maintain that the hard sandstones overlying some of the coal beds can not be made to break. However, it is known that in other fields, where hard sandstone occurs above the coal, the sandstone has been compelled to break, explosives being occasionally used if necessary. It is said also that one particularly obdurate sandstone is about 40 feet above one of the coal beds, hence could not be reached by explosives. However, the open space made by the removal of the 3 to 4 feet of coal would probably be filled and the weight taken before the hard sandstone 40 feet above the coal would be reached. It is not thought that there would be any trouble from gas gathering beneath the sandstone roof, as a fresh current of air would be on the face at all times.

CONCENTRATION OF WORK AND HAULAGE.

As compared with the present system, a panel system such as outlined would greatly concentrate work. Each panel would produce daily 150 or 175 tons of coal, which would be delivered to the levels by a hoist man and a rope rider, or approximately 75 or 85 tons a man, as compared with the present output of 25 to 30 tons for each mule and driver. If the labor agreement should require, as at present, that the cars be pushed one way by the company, this could be accomplished by paying a small additional sum to the miners, as is done in Wyoming mines, where an additional 2 cents a ton is paid the miners for pushing cars both ways.

With a daily production of 150 to 175 tons a panel, only 6 or 7 panels would be required for an output of 1,000 tons, and this could

nly under favorable condi-
Of 59 mines examined in
queezes. If a panel system
pitches of 10° to 30°, and
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HAULAGE.

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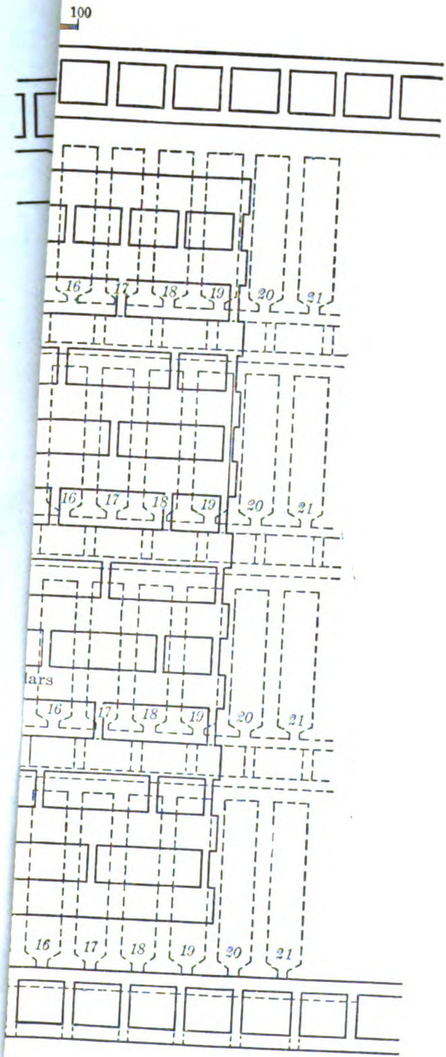

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be obtained from workings extending over less than 70 acres, with two levels, each 1,700 or 1,800 feet long, on each side of the slope. A mine of equal capacity worked under present methods covers four to five times as much territory and costs relatively much more to maintain. Even after the nearer panels had become worked out and the length of level haulage roads increased, the work would still be concentrated because each panel, or 600 feet length, would have at least 20 loaders, as compared with the general practice in Oklahoma of having 10 or possibly 15 men to a level entry, which may be more than a mile long.

Moreover, a level having two, three, or more panels, each producing 150 to 175 tons per day, may thus produce 300 to 500 tons daily at a distance of 1, 2, or more miles from the main slope, by using electric locomotives, the installation of which would not pay if only 50 to 75 tons a day, which is more than the average production per level in Oklahoma mines, were being handled. The haulage cost, which averages more than 20 cents per ton, would be lowered 25 to 50 per cent by installing the panel system with electric locomotive haulage on levels. This system would also result in the elimination of mule haulage, a consummation greatly desired by practically all mining men. The elimination of mules will also, in many mines, make brushing of haulage roads in entries and rooms unnecessary. Brushing is not only expensive but induces future roof troubles, many of which would be avoided if the original roof were not broken.

YARDAGE AND DEAD WORK.

In present mining, with pitches exceeding 15°, rooms are rarely driven more than 125 feet and frequently only 80 feet, the shorter room length being used where the pitch is too steep to place cars at the face, and not steep enough to permit the coal to slide by gravity, even when sheet-iron chutes or flat plates are used. This necessitates driving levels off the main slope at intervals of 125 to 150 or 175 feet, whereas with the proposed panel system levels would be needed only about every 650 or 700 feet.

As compared with the 100-foot rooms and 10-foot room pillars of the present system, the use of a panel system with room pillars 26 feet wide would reduce the proportion of coal from narrow work from about 27 to 17 per cent. This would greatly increase the percentage of large-size, salable coal, as narrow work tends to produce fines.

Moreover, the panel system would reduce the cost of yardage, said by Oklahoma operators to average 30 cents per ton for this field, to about 19 cents per ton. There would be only one level entry in a mine to keep timbered and in which track would have to be maintained, whereas under the system in use there are three or four such levels. The change would reduce the number of track and timber men required, as the panel dip entries are abandoned as soon as the pillars are pulled. By the present system track must be maintained in levels long after a large percentage of the rooms has been abandoned.

Where the pitch is less than 15°, rooms are driven approximately 200 feet under the present system, and approximately 14 per cent of the coal comes from narrow work, as compared with 17 per cent with the panel system. But this proportion of coal from narrow work in the panel system can be reduced in nongaseous mines by driving only one panel or butt entry instead of the usual pair, and providing ventilation by immediately turning rooms off the butt or panel entry and converting the first crosscut between rooms into the parallel air course. However, as the thickness of room pillars with the present system, 10 feet or less, does not permit pulling, the panel system will ultimately yield a much greater tonnage per foot of narrow work.

As previously stated, the use of a panel system would concentrate haulage and permit the use of electric locomotives, thus reducing and in many mines eliminating the roof brushing now necessary for mule haulage. Driving rooms across the pitch would also tend greatly to reduce roof falls and timbering in rooms, as it is noticeable in Oklahoma mines that in wide places, such as partings, on level entries the roof holds far better and with much less timbering than in rooms driven up the pitch. Moreover, if the roof were not broken by brushing it would stand much better.

FIRES AND EXPLOSIONS.

Fires are frequent in Oklahoma mines, particularly at shot-firing time. The fires are sometimes caused by the use of black blasting powder in dusty or gaseous places. One company operating several mines is said to have averaged one fire a week for a 10-year period. In many instances it has been necessary to seal entire mines at the shaft or slope mouth for various periods, and resort has also been had to flooding.

The use of a panel system would permit machine mining, facilitate the use of permissible explosives, and thus practically eliminate fires. Even if a fire should be started through the ignition of gas, or any other cause, a panel system properly maintained would permit sealing such a fire with about four stoppings, whereas under the present system several stoppings are required to seal a fire. In a mine worked by panels an explosion of limited violence may be confined to the panel in which it originated, as was done in a panel mine in Pennsylvania in 1915. By the use of suitable rock-dust barriers placed in the panel entries near their intersections with the levels, even a violent explosion might be confined to the panel in which it originates and at a comparatively small cost.

VENTILATION.

The general practice in Oklahoma is to split the intake air at the foot of the slope, giving one split for the right-hand side and one for the left-hand side of the mine. It is generally held that further splitting is impracticable, although in mines known as gaseous, splitting at the various levels has proved satisfactory. With the panel system the levels intersect the main air courses (slopes) at only every 600 or 700 feet, as compared with every 125 to 250 feet with the present system, and the slopes (main air courses) are not intersected at any point except at levels, thus minimizing opportunity for leakage and short-circuiting of air. Moreover, along the levels, which are auxiliary air courses, openings are made only at intervals of 500 or 600 feet, as compared with every 35 or 40 feet in the present practice. In each panel are only about 20 men and the ascensional ventilation used may be easily controlled by regulators and small overcasts. Air from one panel may be used in the next panel, or, if for any reason it is desirable to isolate the ventilation from a panel from other workings, the return from that panel may be brought into the main return by an overcast. When a panel has been abandoned it may be sealed or ventilated, as desired, with comparatively little trouble. In short a far more positive and flexible system of ventilation than the one now used can be had, and the cost of additional overcasts is offset by the decreased number of stoppings needed.

USE OF MACHINE MINING IN ROOMS.

Of the 59 mines visited in 1915, 51 were shooting off the solid in the rooms. At many mines bad roof conditions were complained of. These may well be due to the stresses caused by leaving small room pillars, to leaving the pillars in, and to using the heavy charges necessary in shooting from the solid. In general, if the coal is undercut and moderate charges of explosives are used, the roof in Oklahoma mines is distinctly better than that in many other coal fields. This has been proved in the mines that use machines. In 51 of the mines examined, the pitch is less than 30°, hence the introduction of a panel system for mines with pitches of 5° to 30° would permit the use of chain machines in each of the 51, for roof and floor conditions are generally favorable and none of the mines are wet enough to prevent the use of machines.

Coal shot off the solid in Oklahoma mines rarely yields as much as 45 per cent of 2-inch lump, whereas undercut coal will yield 55 to 65 per cent and even 80 per cent of lump coal. Domestic lump coal is in demand at $3 to $4.50 per ton, according to the season, whereas slack

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is often unsalable at $1 per ton. In shooting off the solid, a keg of blask blasting powder (25 pounds) will average only 14 tons of coal brought down, whereas in blasting undercut coal in the same mine a keg of powder will average 50 to 60 tons.

In some Oklahoma mines rather soft "dirt bands" occur immediately above or below the coal or as partings, and shooting off the solid breaks the "dirt" into fine pieces, which can be removed only by expensive picking and washing. In mines where the coal is undercut it has been found that the "dirt" can be removed underground in large pieces, and the quality of the coal as shipped is greatly improved, and the expense of washing the fine coal is avoided. There is a wage "differential" in Oklahoma of 7 to 14 cents per ton in favor of machine-mined coal, and machine coal pays only two-thirds of the yardage of coal shot from the solid.

The cost of installing a short-wall machine unit, including mining machine, boilers, generators, wiring, and other equipment complete, is estimated not to exceed $3,300,[a] and a machine in a panel mine working in coal pitching more than 20° will readily average three places an 8-hour shift, or 45 tons a shift in a 3-foot bed, and 60 tons in a 4-foot bed. With 150 working days per annum each machine would produce an annual output of 6,750 tons in 3-foot coal and 9,000 tons in 4-foot coal. With a wage "differential" of 7 cents a ton each machine would save $472.50 in wages annually in mining a 3-foot bed, to which amount would be added the saving due to the difference in cost of yardage. Yardage, including brushing, is said to cost 30 cents a ton in Oklahoma and as the yardage "differential" is one-third the saving would be one-third of 30 cents a ton, or 10 cents a ton, which on 6,750 tons would be $675 annually in mining a 3-foot bed. Hence, the annual saving per machine in 3-foot coal, solely from the difference in wages and yardage, would be $675 plus $472.50 or $1,147.50. From this should be subtracted the cost of repairs and maintenance for the machine used, which should not in any event reach 2 cents a ton, and the depreciation charge.

It will readily be seen that each machine unit would earn at least 25 per cent annually in wages saved, and with the amount gained in the improved quality of coal, better roof conditions, etc., would almost pay for itself annually. If the coal is 3½ or 4 feet, or thicker, the advantage of machines is more marked than in mining coal 3 feet thick or less.

CONCLUSIONS AS TO ROOM-AND-PILLAR PANEL SYSTEM.

The introduction of a new system of mining into an established mining district is accomplished only with much expense and diffi-

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[a] Cost is based on January, 1915, prices.

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culty, especially where a new wage scale must be negotiated. Yet this has been done in various mining districts in the United States, and the change should be possible in Oklahoma. In opening a mine the panel system will not yield as quick returns as the present system used in Oklahoma, also the cost of equipping a panel mine will be greater. The difficulties that must be met in Oklahoma have been overcome in other coal-mining districts and when these are overcome the advantages from almost any standpoint will be so great as to entirely overshadow the difficulties.

PANEL LONG-WALL SYSTEM.

It is thought that those coal beds having steep dips can be worked most economically and profitably by some method of long-wall mining, probably panel long-wall mining, as it seems that mining machines could be operated most successfully by this system and the roof weight controlled better. This method of working should be especially suitable for Oklahoma mines because of the intermittent character of the coal trade in Oklahoma, and because the conditions responsible for the excessive cost of dead work in this coal field as compared with other fields could be avoided.

By adopting the panel long-wall system less narrow work and less brushing should be necessary and the cost of production should be materially reduced. It is true that a new scale of wages and tonnage rates would be necessary before this system could be established, but this detail should be easily disposed of once the miners understand the benefits to be derived from the new system. Under this plan the miner would derive the greater part of his daily earnings from loading coal and not from doing dead work, and he would be working in much better air and under superior working conditions, the turn would be better, and he would have a higher average tonnage to load daily than at present.

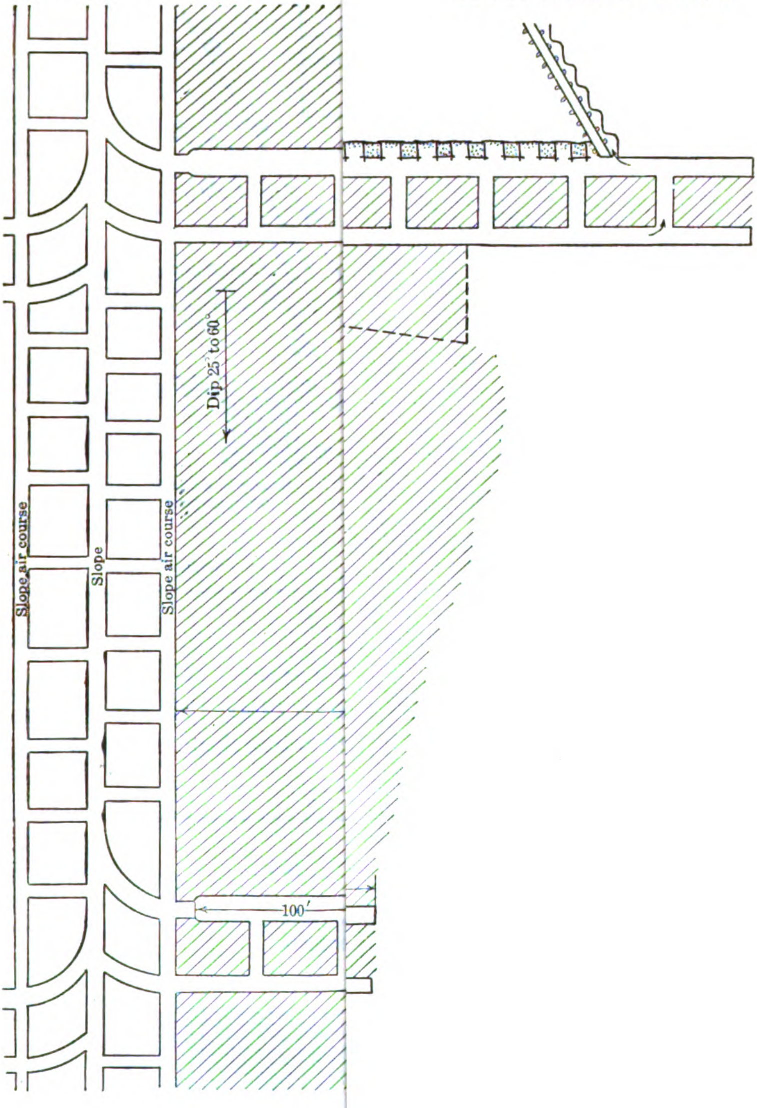
PANEL LONG-WALL ADVANCING SYSTEM.

In the panel long-wall advancing system (see Pl. IV) a slope is driven from the outcrop down the dip, or pitch, of the coal bed, with an air course on each side of the slope, as is the present practice, but with the following modifications: A surface pillar 300 to 500 feet thick is left along the outcrop to prevent influx of surface water to the mine workings, the first lifts, or cross entries, being turned at distances of 300 to 500 feet from the outcrop, or mouth of the slope. The pillars between the slope air course and the first rooms on the cross entries are thicker than is the present practice. The cross entries are turned directly off the slope, as at present, but a slope barrier pillar 150 to 300 feet thick is left just inby the slope air course. Double cross entries are turned off the slope at 300 to 400 foot centers. A chain pillar 30 feet thick is left between the cross entries and the air course below, and the upper entry is made the haulage entry.

When the cross entry and the air course below it and parallel to it have been advanced to the limits of the slope barrier pillar, two rooms are turned off the cross entry, at right angles to it. These rooms are driven directly up the pitch, as in present practice, crosscuts being driven at proper intervals between the two rooms in order to properly ventilate them, as the work progresses. These rooms are holed through to the air course of the cross entries above for the purpose of ventilation and are driven narrow for the last 50 feet.

As soon as the rooms have been driven the inby rib of the inby room, beginning at a point 40 to 50 feet below the air course of the cross entries above and extending to the entry below, is made the working face. In practice this face would probably be kept at an angle with the entry (as shown in Pl. IV) in order to protect each loader from falling coal or rock from the working places above his place. The angle of the working face would vary with the dip and the cleat of the coal. The coal, or in some mines, the underclay, would be undercut with short-wall electric mining machines to a depth of 3 to 5 feet. A pulley would be hung on a prop at the upper end of the working face to facilitate hauling the machine up and down. As the face is advanced, a barrier pillar 40 to 50 feet wide (measured on the dip) would be left just below the air course of the upper cross entries to protect the haulage way and the air course. At intervals of 100 to 150 feet along the strike openings would be driven through this barrier pillar to the air course in order to simplify the ventilation. If the cross entries, exclusive of the top barrier pillar, were driven 300 feet apart and the working face kept at an angle of 60° with the entry, there would be 345 feet of working face, which could be cut with one machine of the short-wall type in one shift—probably at night. Each miner would have 20 to 35 feet of face, depending on the dip and the thickness of the coal, the manner of loading, etc. To steady the roof about three or four lines of props would have to be maintained parallel to the long-wall face, and as each cut was taken from the face the line of props farthest from the face would be removed. This would permit reusing props and caving the roof as work progressed. It is not thought that it would be necessary to build pack walls to receive the weight of the roof, but such walls, if necessary, could be readily built of material blasted from the roof.

If the coal dips more than 30° self-propelling machines can not be used, although short-wall machines can be and are successfully used



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on such dips; then the face is stepped as shown in figures 1 to 4. A post puncher could then be used to shear, overcut, or undercut the coal, or the coal could be blasted off the solid, if necessary. A face step is 14 feet high and 8 feet deep. Two of these steps give sufficient working face for one man. For dips of more than 30° a sheet of No. 16 steel plate 3 feet high is stood vertically on edge along a row of

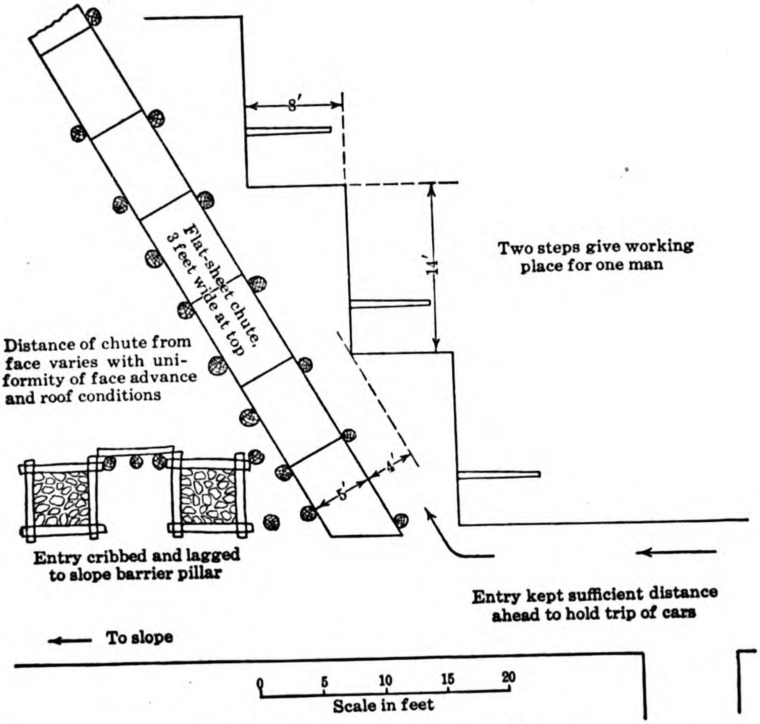
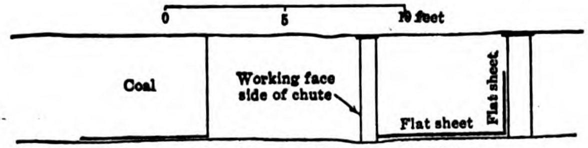
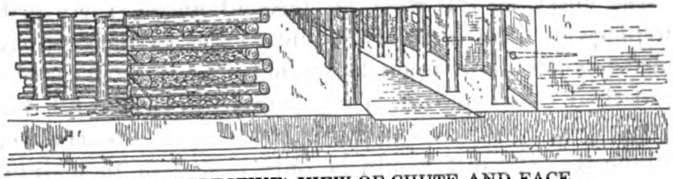

8'
Flat-sheet chute, 3 feet wide at top
14'
Two steps give working place for one man
Distance of chute from face varies with uniformity of face advance and roof conditions
4'
5'
Entry cribbed and lagged to slope barrier pillar
Entry kept sufficient distance ahead to hold trip of cars
To slope
0
5
10
15
20
Scale in feet

FIGURE 1.—Plan view of chute and face.



SECTION THROUGH CHUTE (FIG. 3)



END (PERSPECTIVE) VIEW OF CHUTE AND FACE

FIGURE 2.—End view of chute and face.

props and parallel to the working face. The distance between this sheet and the working face will vary with the uniformity of the face advance and the roof conditions, though it is believed that 4 to 5 feet would be enough. For a flatter dip, chutes could be laid. No. 16 steel in sections 8 feet long, probably 3 feet wide at the upper end of the chute and increasing to 5 feet at the lower, or spout, end could be used for the chute bottom. These flat sheets could be bolted, or hooked, together and onto the vertical sections. A post puncher machine could easily be pulled up and let down such a chute and could be held in position for cutting with props.

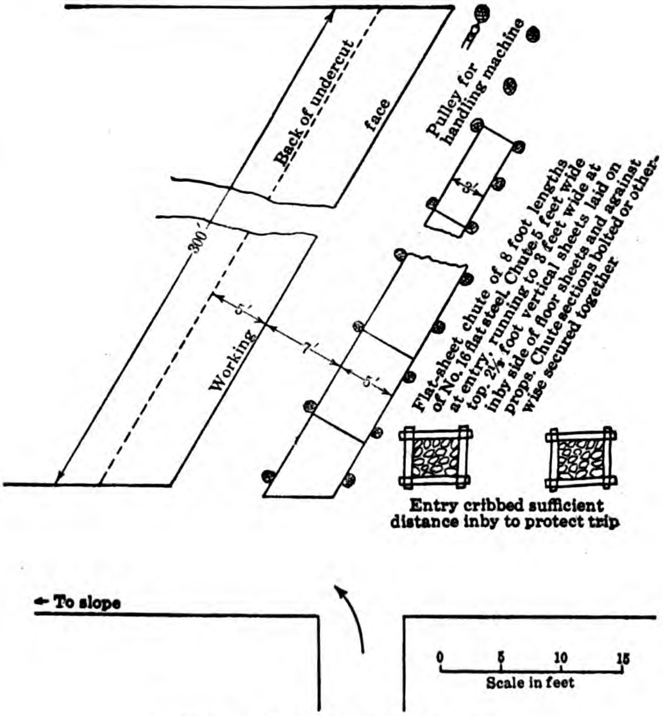

Back of undercut
face
Pulley for handling machine
300'
3'
5'
7'
5'
Working
Flat-sheet chute of 8 foot lengths of No. 16 flat steel. Chute 5 feet wide at entry, running to 3 feet wide at top. 2½ foot vertical sheets laid on inby side of floor sheets and against props. Chute sections bolted or otherwise secured together
Entry cribbed sufficient distance inby to protect trip
← To slope
0
5
10
15
Scale in feet

FIGURE 3.—Plan of machine-cut face.

Timber cribs made of 4-foot props could be built along the top side of the entry as the working face advanced, these cribs being held in place by iron pins driven into holes drilled into the floor. These cribs can be built upon loose coal slack, or pieces of slate, to permit of their easy removal, if necessary, and can be filled with gob or left empty as conditions require. If the bottom entry were made the haulage way, then it would be only necessary to maintain these cribs along the entry from the working face back to the last inside sly (dip switch). The cross entries would probably be driven by a post puncher and would be kept about 80 feet in advance of the lower end of the long-wall face in order to give room for the storage of a trip of empty cars. In a 4-foot bed a panel height of 350 feet would yield approximately 50 tons of coal per foot of advance. If the panel face was undercut to a depth of 4 to 5 feet and the coal loaded each day 200 to 250 tons could be obtained from a panel, compared with a production of 50 to 75 tons per cross entry under the present system. The roof caves or is shot down as the face advances, the lines of props being advanced as the working face advances.

The bottom would be cut away sufficiently on the entry to allow the mine car to receive the coal directly from the spout without the necessity of shoveling (see fig. 4). Where the coal bed is too flat for chute work the coal, if the bed is thick enough, could be handled by laying track and running cars along the face, or, if thin, by means of a conveyor laid along the face and cars on the entries. In the first plan the empty cars would be brought in at the top of the panel and the loaded ones taken out at the bottom.

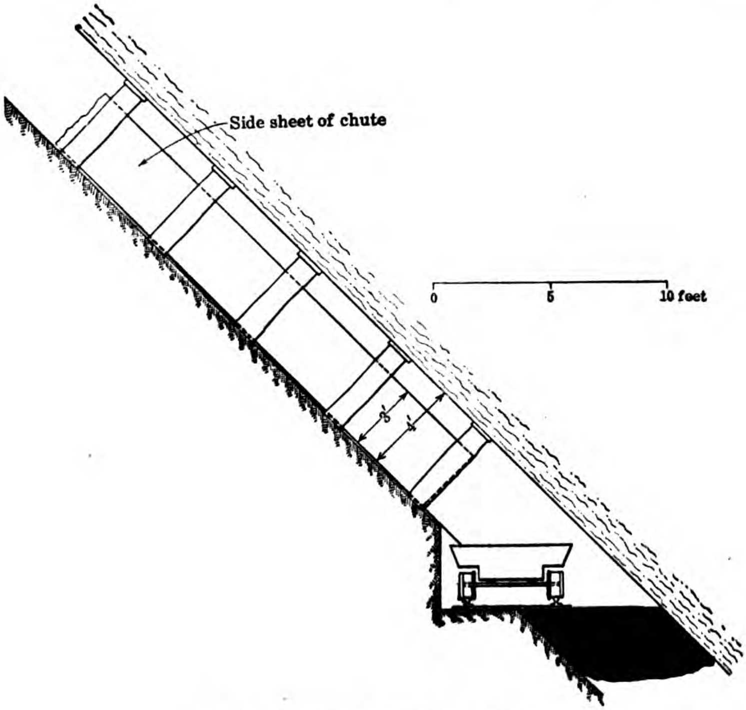


FIGURE 4.—Side elevation of chute.

Each panel face should be advanced to a distance of 2,000 to 3,000 feet. The latter distance is more than the limit of economical animal haulage in cross entries in this field under the present system of mining, but under the proposed system the haulage would be greatly

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simplified and the loading centralized, and it would probably prove economical to drive the entries 3,000 feet or even farther.

The cross entries, or lifts, can be advanced in the manner shown in Plate IV, so that the weight will come on uniformly. If this is done, however, the cross entries above and below these two cross entries should be left unmined in order to avoid possible squeezes. Two working panels on each side of the slope should yield a sufficient output. A somewhat similar method of mining practiced in the steep-pitching coal beds of Washington has been described by Ash.[a]

PANEL LONG-WALL RETREATING SYSTEM.

The details of the panel long-wall retreating system, which are shown in Plate V, would be very similar to that previously described. The essential differences are as follows: In the retreating system the cross entries would be driven to the panel limits, 2,000 to 3,000 feet, before the coal in the panel was touched. Two rooms would be driven for ventilation as before, but this time at the inby instead of the outby end of the panel. The face would then be brought back, starting at the outby rib of the first room, as shown in Plate V. The coal on the lift above would probably have been worked out by this time and therefore it would not be necessary to leave the entry barrier pillar as in the advancing system; in fact, it is possible that the entry chain pillar from the lift above might also be extracted.

An additional advantage would be the lesser cost of maintaining the haulage entries, and the smaller slope barrier pillars necessary, as the main weight would be relieved before the workings neared the slope. The disadvantages are that a longer time is required to open the long-wall face, and that more money would have to be spent before the panel began producing coal. However, the last ton of coal produced in such a mine would be the cheapest, whereas under the system in use it is the dearest.

It would be necessary to crib the top entry for about 80 feet inby the retreating long-wall face in order to keep the entry open for storing a trip of empties. The top entry could readily be made the haulage entry, as it would be in solid coal outby the working face. By placing the cribs on loose dirt, most of the timber in the cribs could be recovered and used again as the working face progressed outby.

When the panel had been mined to a point 150 feet inby the slope, measured along the strike, work would be stopped, and a pillar left as a protection to the slope.

With the advancing system an extraction of 80 or more per cent from the panel would be obtained in the advance work, with a

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[a] Ash, S. H., Working a steep coal seam by long-wall methods: Coal Age, vol. 9, Apr. 29, 1916, pp. 742–745.

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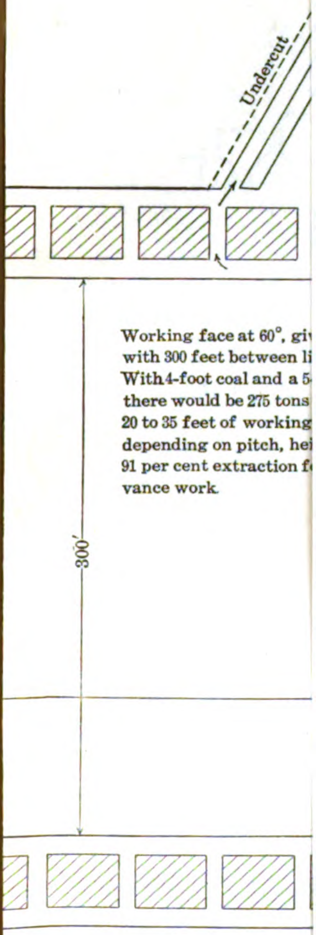

Working face at 60°, gi
with 300 feet between li
With 4-foot coal and a 5
there would be 275 tons
20 to 35 feet of working
depending on pitch, hei
91 per cent extraction f
vance work.

ND-PILLAR WORKINGS AR

possible additional extraction from the entry, chain, and barrier pillars.

With the retreating system an extraction of 91 to 95 per cent would be obtained from the panel, depending on whether the entry chain pillar was brought back by the workers from the lift below.

COMPARISON OF LONG-WALL METHODS WITH PRESENT METHODS.

Either of the suggested methods, as compared with the system in use at present, would show the following advantages:

Panel long-wall systems compared with present system.

	Panel long-wall systems.	Present room-and-pillar system.
Extraction, per cent	80 to 100	40 to 60.
Loading and mining	Concentrated	Widely distributed.
Haulage	Cheaper and more efficient	Inefficient.
Ventilation	Safer and more economical	Ineffectual and inefficient.
Production per entry, tons[a]	200 to 275	40 to 75.
Production per miner	Greatly increased	3 to 5 tons daily.
Maintenance	Moderate	Heavy.
Expense for narrow work	Light	Do.
Squeezes	Controlled and avoided	Unavoidable and uncontrolled.
Miners' conditions	Improved	Employed only 5 to 6 months in the year.

The panel long-wall system lends itself to the peculiar conditions of the Oklahoma coal fields, where there is a demand for coal during only five or six months of the year, yet the entire mine workings must be kept open at great expense during the remainder of the year for the relatively small amount of coal obtained during the busy season. If some such system as has been suggested had been followed in the Oklahoma field, only one-half of the acreage now opened would have been necessary for the coal produced thus far, and the increase in recovery over present practice would have been 30 to 40 per cent.

In Plate V the present system of working has been interposed on the proposed system to show the contrast between the two systems, one showing chute rooms, the other track rooms. Both are platted from actual survey notes. It will be noted that by the new plan the necessity of driving narrow crosscuts between the rooms, and narrow room necks is avoided, with the expense for yardage entailed. Lifts or levels are driven every 300 feet along the slope, as compared with every 125 to 200 feet at present, thus reducing this kind of narrow work 25 to 50 per cent. It is estimated that in mines shooting off the solid the proportion of fine coal to the total output is increased 15 per cent through narrow work.

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[a] Per ton of 2,000 pounds.

Moreover, in many mines now working under the old system the roadways in all rooms must be brushed and this expense is additional to the yardage for driving the narrow work in the coal alone. With the new plan nearly all the narrow work and most of the brushing is eliminated, more lump coal is produced, as it is all wide work, and advantage may be taken of the cleat to facilitate mining and produce the maximum proportion of lump coal.

PROPOSED PANEL LONG-WALL ADVANCING SYSTEM.

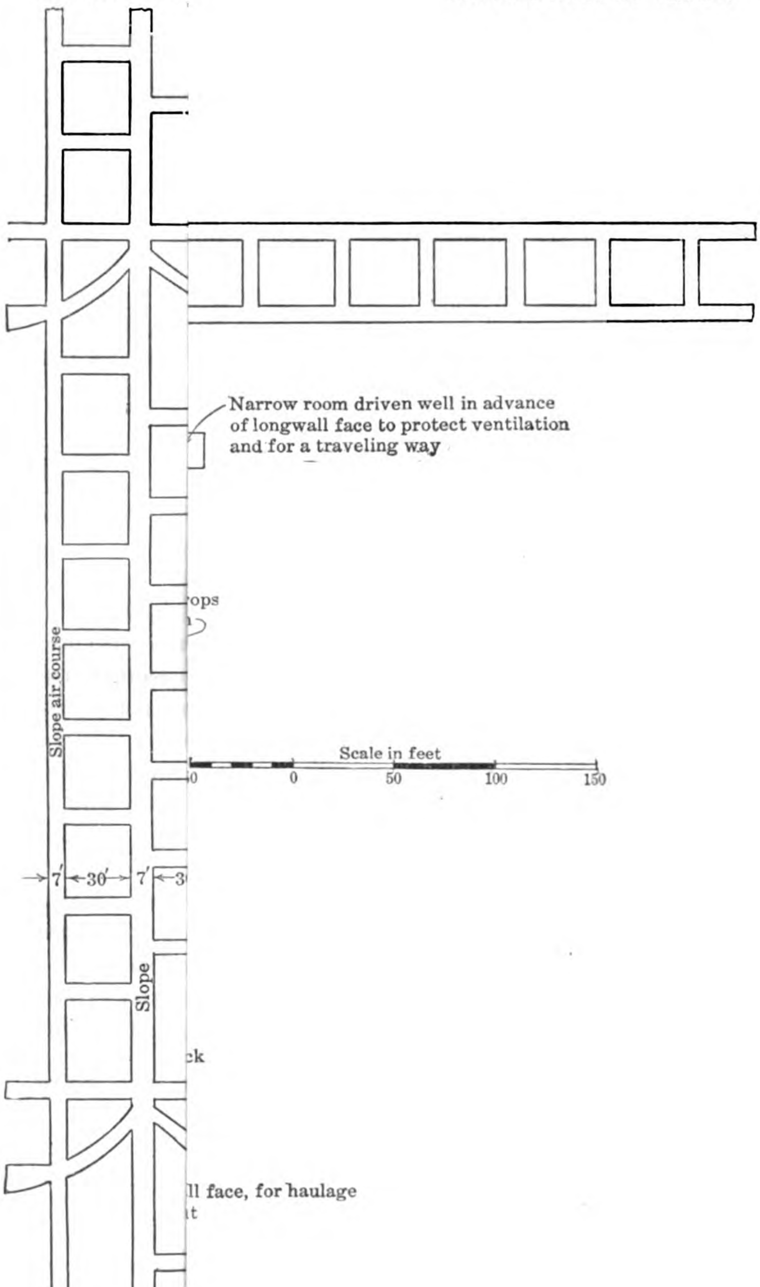
Frequently in advancing long-wall work, especially under the Scotch or "45°" system, such as is followed in the coal mines of northern Illinois, the face closes.

Usually when this occurs it is necessary to cut through the solid coal at considerable expense and delay in order to reestablish the working face and to restore the ventilation. Plate VI shows a method of working similar to the advancing panel long-wall system shown in Plates IV and V, except that the working face is driven at a considerable angle (about 40° to 60°) with the line of dip. Two rows of props, spaced as shown in Plate VI, are used to regulate the weight on the working face. Two narrow places are driven at an angle of 30° to 45° across the dip, up to what is to be the upper end of the long-wall face. These places may be about 16 feet wide, with a 25-foot pillar between, the intent being to drive them wide enough to minimize payment of yardage. The outside, or outby, place is begun at a point 300 feet from the air course of the main slope. Both places should be driven to within 50 feet of the haulage way on the level above.

The barrier pillar left above the long-wall face is 50 feet thick along the dip and has crosscuts every 30 feet along the strike. A passage about 16 feet wide, or wide enough to minimize the payment of yardage, is driven below the barrier pillar to provide ventilation and an escape way in the event of the working face closing. A dip switch is driven from the lower end of the long-wall face to the main haulage way below, cribs being carried to protect the face. The coal from the escape way above the face and from the crosscuts above is loaded into cars and hauled by means of a small auxiliary system to the upper end of the face where it is delivered to the haulage system there used.

The panel long-wall system described above would have the following advantages for Oklahoma mines:

1. Machines could be used in all mines; even in those mines where the dip was the greatest the working face could be run at such an angle with the dip that mining machines of the short-wall type could be used successfully.


Narrow room driven well in advance of longwall face to protect ventilation and for a traveling way
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PROPOSED TION AND SAFETY OF MEN IN EVENT OF

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2. The amount of narrow work, one of the greatest expenses in the rise-room system now in use, would be a minimum.

3. Haulage costs would be much lower than in the rise-room system, as the loading would be concentrated; also there would be no need for hoists with hoist men and rope riders as would be necessary in the proposed room-and-pillar panel system described on pages 11 to 21.

4. The recovery of coal per acre mined would be greater than by the room-and-pillar system.

5. The initial cost of opening a mine would be much less than under the room-and-pillar system, because the proportion of narrow work would be less and the maximum output would be attained more quickly.

6. When the long-wall face was once opened it would yield the maximum daily tonnage, and this tonnage, barring accidents, would be uniform during the life of the mine, whereas in the room-and-pillar panel system the maximum output would not be realized until all the rooms had been turned and widened to full width, and this output would vary with the working out of the rooms.

7. The daily tonnage per machine unit would be much greater than in the room-and-pillar panel system as the machine would be at work almost constantly, whereas in room-and-pillar workings the machine must be moved from one working place to another and is cutting coal for only a part of the time.

8. Ventilation costs would be reduced and ventilation made more simple and efficient.

9. If this new method of working were adopted throughout the Oklahoma coal field, labor conditions and mining conditions would be uniform, whereas in the room-and-pillar system there would be differences in yardage work, dead work, and other factors.

10. It is probable that the miners could be educated to the panel long-wall system much more rapidly and their work rendered much more efficient than under the panel room-and-pillar system.

PROPOSED ROOM-AND-PILLAR RETREATING SYSTEM FOR PITCHES UP TO 12°.

A plan for a room-and-pillar system of mining coal, for pitches up to 12°, on the retreat after the area to be worked out has been developed, is shown in Plates VII and VIII.

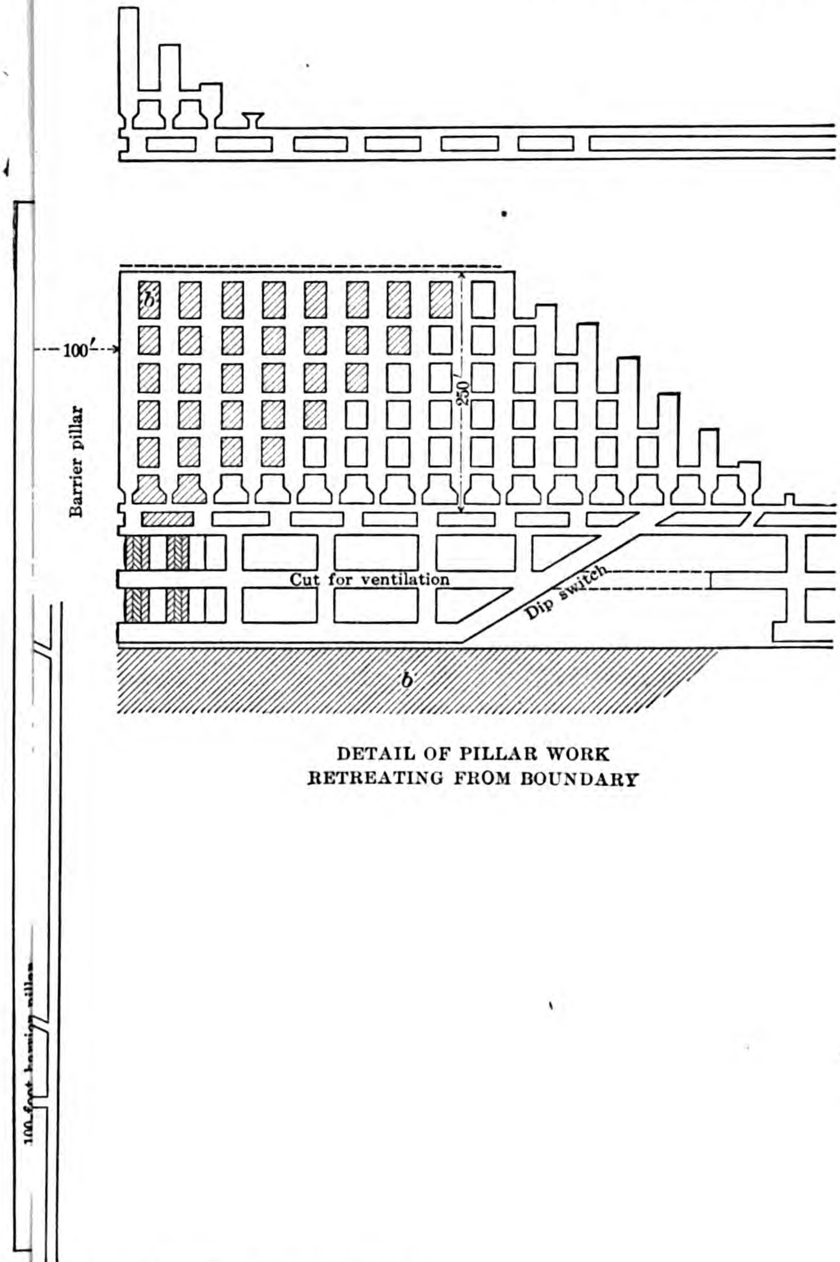
The adoption of this plan presupposes the possession of ample capital on the part of the lessee. The property would have been prospected by means of diamond drills, and the outcrop well defined before mining was begun. A block of coal land embracing a square mile in area would be opened by driving a main slope and parallel air courses from the outcrop directly down the dip of the coal bed to the boundary of the tract before any levels were turned. When the slope had reached the boundary of the tract cross entries, or lifts, would be turned off each side of the slope as in present practice.

A barrier pillar 145 to 150 feet thick would be left between the slope air courses and the first room. Rooms 20 feet wide, on 50-foot centers, and having 30-foot pillars, would be driven directly up the dip 100 to 250 feet, depending upon the degree of dip. The rooms would be widened on each side and be turned off entries which were 10 feet wide, with a 25-foot pillar between the entry and the air course below the entry. The entry would be the haulage way and a parting would be provided at the mouth of the entry to facilitate haulage. A barrier pillar 120 feet thick would be left above the ends of the rooms and below the second lift from the face of the slope.

All rooms on the first lifts would be turned and worked up to the barrier pillar before any rooms would be turned off the second lifts, although these would be finished before robbing of the room pillars on the first lifts was begun. All the rooms on the second lifts would be turned at the same time.

The room pillars on the first lift would be strong enough to prevent squeezing while the rooms on that lift were being worked to their limits, and after the rooms had been worked out the barrier pillar would prevent any squeeze extending to the area to be worked by the second lifts, and these would be progressing to the boundary while the room pillars of the first lifts were being robbed. The barrier pillar between the first and second lifts would be robbed from the second lifts through dip switches. As the first lifts would be down the dip from the second lifts, any weight coming on the workings as a result of pillar robbing or other mining work on the first lifts would be confined to them and prevented from extending to the second lifts by the strong barrier pillars shown. The rooms could be driven straight up a 12° dip, and mining machines should be able to climb wooden tracks in such rooms.

In order to facilitate ventilation and prevent accumulations of gas while the pillars were being drawn, crosscuts through the barrier pillar could be driven from the air course of the second lift to the faces of each fourth or fifth room on the first lifts. But the rooms at the inner end of the lifts would be advanced first in sufficient number to constitute a break or cave line after the pillars are once begun to be withdrawn, and an equal number of rooms should be advancing so as to establish a line of advance similar to the line of retreat. If rooms were all driven to their boundary at one time along an entry half a mile long there would be a large number of rooms idle while the robbing work retreated, so it is better to advance the rooms just as fast as the pillars are withdrawn.



DETAIL OF PILLAR WORK
RETREATING FROM BOUNDARY

E WORK; *b*, PILLAR WITHDRAWN.

The method of working just outlined would be adapted to pitching coal beds having a poor roof and underlain with thick beds of soft fire clay. The entire area to be mined could be prospected before development was begun. Any faults, rolls, slips, or other serious obstructions to mining would be discovered during the advance work and could be left in pillars or avoided in subsequent mining. Drainage, haulage, and timbering costs would decrease with the life of the mine. Where the slope could be driven to meet a vertical shaft sunk at the dip end of the property the method should prove very economical. This method of working is being introduced into two of the mines in the Coalgate district.

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